hamshire should end off at an anticline, probably faulted, in the region about Melton Mowbray. Such an anticline has an east-and-west trend, and carries round the strike of the Coal Measures from its general north-east-and-south-west to an east-and-west direction. The Rempstone-Melton Mowbray magnetic disturbances, therefore, are interpreted as additional evidence of the existence of a fault which in the underlying Palæozoic rocks may have a considerable throw; and it is regarded as probable that a sill of dolerite is displaced by this fault, or that an irregular mass of dolerite is intruded along it.

The hope is expressed by the author that a like method of attack may prove to be of use as a guide to the divining of the position of faults beneath a cover of unconformable strata in other districts—*e.g.* in concealed coalfields, where dolerites or other rocks containing a high proportion of magnetite are present. Unfortunately, however, or fortunately from the point of view of the coal miner, dolerites are not an invariable concomitant of coal seams, and it therefore follows that the use of the method in determining the limits of concealed coalfields would appear to be somewhat restricted.

British Crop Production.[1]

By Dr. Edward J. Russell, F.R.S.

Crop production in Britain is carried on in the hope of gain, and thus differs fundamentally from gardening, which is commonly practised without regard to profit and loss accounts. Many poets from times of old down to our own days have sung of the pleasures to be derived from gardening. But only once in the history of literature have the pleasures of farming been sung, and that was nearly two thousand years ago.

> Ah! too fortunate the husbandmen, did they but know it, on whom, far from the clash of arms, earth their most just mistress lavishes from the soil a plenteous subsistence.—"Georgics," Bk. II., i., 458 *et seq.*

"Did they but know it"! Even then there seem to have been worries!

This seeking for profit imposes an important condition on British agriculture: maximum production must be secured at the minimum of cost. This condition is best fulfilled by utilising to the full all the natural advantages and obviating so far as possible all the natural disadvantages of the farm—in other words, by growing crops specially adapted to the local conditions, and avoiding any not particularly well suited to them.

From the scientific point of view the problem thus becomes a study in adaptation, and we shall find a considerable interplay of factors, inasmuch as both natural conditions and crop can be somewhat altered so as the better to suit each other.

It is not my province to discuss the methods by which plant-breeders alter plants; it is sufficient to know that this can be done within limits which no one would yet attempt to define. The natural conditions are determined broadly by climate and by soil. The climate may be regarded as uncontrollable. "What can't be cured must be endured." The scheme of crop production must, therefore, be adapted to the climate, and especially to the rainfall.

The rainfall map shows that the eastern half of England is, on the whole, drier than the western half. In agricultural experience, wheat flourishes best in dry conditions and grass in wet conditions; the vegetation maps show that wheat tends to be grown in the eastern and grass in the western part. The strict relationship is that seed production is appropriate to the drier, and leaf production to the wetter, districts.

The great soil belts of England south of the Trent run in a south-westerly direction; north of the Trent, however, they run north and south. A heavy soil, like a wet climate, favours grass production; a light soil, like a dry climate, is suitable for arable crops. The great influence of climate is modified, but not overridden, by the soil factor.

The arable farmer grows three kinds of crops: corn, clover or seeds hay, and fodder crops for his animals or potatoes for human beings. The same general principles underlie all, and as corn crops are of the most general interest (though not necessarily of the greatest importance), they will serve to illustrate all the points it is necessary to bring out. We have seen that wheat is cultivated more in the eastern than in the western portion of the country. The figures for consumption and production are as follows:—

Millions of Tons per Annum.

	Consumption in United Kingdom	Production in England and Wales			Production in United Kingdom		
		Before war 1914	1918	1919	Before war 1914	1918	1919
Wheat ...	7·40	1·6	2·3	1·8	1·7	2 6	2·0
Barley ...	1 96	1·2	1·2	1·1	1·6	1·5	1·3
Oats ...	4 30	1·4	2·0	1·6	3·0	4·5	4·2

During the war very serious attention was paid to the problem of reducing the gap between consumption and production. A working solution was found by lowering the milling standard, retaining more of the offal, and introducing other cereals and potatoes; a very considerable proportion of the resulting bread was thus produced at home. But the war-bread did not commend itself, and disappeared soon after the armistice; since then the consumption of wheat has gone up, and the divergence between consumption and production has again become marked. There is no hope of reducing consumption; we must, therefore, increase production. Additional production may be obtained in two ways: by increasing the yield per acre, and by increasing the number of acres devoted to the crop.

The yield per acre is shown in the following table:—

Measured Bushels per Acre.[2]

	(1908–17) Average yield per acre		A good farmer expects	Highest recorded yield
	England and Wales	Scotland		
Wheat ...	31·0	39·9	40 to 50	96
Barley ...	31·9	35·4	40 to 60	80
Oats ...	39·3	38·9	60 to 80	121

The average results include bad farmers and bad seasons; the good farmer expects to do considerably

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[1] Discourse delivered at the Royal Institution on Friday, February 20.

[2] Unfortunately the terms "bushel" and "quarter" (8 bushels) lack definiteness, being used officially in three different senses and unofficially in several others also. The following are some of the definitions of a bushel:—

	Official Statistics. A definite volume having the following average weight lb.	Corn Returns Act. Volume occupied by following weight lb.	Grain Prices Order. Volume occupied by following weight lb.	Frequent Practice. Volume occupied by following weight lb.
Wheat ...	61·9	60	63	63
Barley ...	53·7	50	55	56
Oats ...	39·3	39	42	42

better, but he has many things in his favour: superior knowledge, greater command of capital, and possession of good land; he will, therefore, always stand above the average. Even his results can be improved the highest recorded yields show what can be done with present varieties and present methods in exceptionally favourable circumstances. The figures give the measure of the scientific problem, which is to discover what changes would be necessary in order to bridge the enormous gap between the average and the best. In three directions progress is possible; we may modify the plant or the soil, or we may mitigate the effects of unfavourable climate.

Before the soil can be brought into cultivation at all it is necessary to carry out certain major operations—draining, enclosing, etc.—which have to be maintained in full order. These lie outside our present discussion; we must assume that they are properly carried out, which is by no means always the case. Given adequate drainage, soil conditions are profoundly modified by cultivation, which has developed into a fine art in England and Scotland, and is, indeed, far better practised here than in most other countries. But it is an art, and not yet a science; the husbandman achieves the results, but no one can yet state in exact terms precisely what has happened. A beginning has been made, and a laboratory for the study of soil physics has been instituted at Rothamsted and placed under Mr. B. A. Keen, where we hope gradually to develop a science of cultivation. For the present cultivation remains an art, and, further, it is essentially a modern art. The medieval implements, as shown in the Tiberius MS. (eleventh century) and the Luttrell Psalter (fourteenth century), were crude, and left the ground in an exceedingly rough condition. Great advances were made throughout the nineteenth century. Robert Ransome, of Ipswich, took out his first patent in 1785 to improve the plough; he was followed in 1812 by Howard, of Bedford, and later by Crosskill, Marshall, Rushton, Fowler, and others, who have made British implement-makers famous throughout the world. Given time and sufficient labour, the good British farmer using modern implements can accomplish wonders in the way of cultivation.

Unfortunately, neither time nor labour is always available. Ploughing is possible only under certain weather conditions, and there are many days in our winters when it cannot be carried out. Unless, therefore, a large staff of men and horses is kept, the work often cannot be done in time to allow of sowing under the best conditions.

The early days of the life of a plant play almost as important a part in its subsequent history as they do in the case of a child. Illustrations are only too numerous of the adverse effect of being just too late for good soil conditions. One from our own fields is as follows:—

Work completed	Seed sown	Yield of wheat 1916. Bushels per acre
Just in time ...	Nov. 24, 1915	26·8
Just too late ...	Feb. 17, 1916	19·3

The farm-horse will not be speeded up, but maintains an even pace of 2½ miles per hour. According to the old ploughman's song still surviving in our villages, an acre a day is the proper rate:—

> We've all ploughed an acre, I'll swear and I'll vow,
> For we're all jolly fellows that follow the plough.

But under modern conditions it is impossible to get more than three-quarters of an acre a day ploughed on heavy land, and the scarcity of teams threatened to bring arable husbandry into a hopeless *impasse*. Fortunately for agriculture, the internal-combustion engine appeared on the farm at a critical moment in the shape of the tractor, and has brought the promise of a way out.

The tractor has two important advantages over the horse. First of all, it works more quickly. Its pace is 3½ miles per hour instead of 2½ miles. It turns three furrows at a time instead of one only; on our land it ploughs an acre in four hours instead of taking nearly a day and a half, as required by horses. There is no limit to the work it can do; even an acre an hour is no wild dream, but may yet be accomplished. It therefore enables the farmer to get well forward with his ploughing during the fine weather in late summer and early autumn, and thus to obtain the great advantages of a partial fallow and of freedom to sow at any desired time. On our own land our experience has been as follows:—

Dates of Completion of Sowings of Wheat and Oats.

Year	Wheat	Oats	
1916	February 17	October 16	Horses only
1917	March 16	„ 17	
1918	January 26	„ 27	
1919	November 26	„ 5	Tractor

Further, if the plough is correctly designed and properly used, the tractor does the work fully as well as horses—even the horse-ploughman admits that. It therefore increases considerably the efficiency of the labourer, which, as we shall see later on, might advantageously be raised. The cost of working is apparently less, though it is difficult to decide this until one knows what the repairs bill will be. In our case the cost is:—

Cost of Ploughing per Acre, Autumn, 1919.

	By tractor s.	d.	By horses s.	d.
Labour	7	7	10	2
Maintenance	—		22	6
Oil and petrol	7	8	—	
Depreciation and repairs ...	6	3	—	
	21	6	32	8
Time taken ...	4 hours		1½ days	

The internal-combustion engine is only just at the beginning of its career on the farm, and no one can yet foresee its developments. It is being used at present simply like a horse, and is attached to implements evolved to suit the horse. But it is not a horse; its proper purpose is to cause rotation while it is being used to pull, and in some cases, indeed, this pull is reconverted into rotary motion.

The second great method of improving soil conditions is to add manures and fertilisers. Farmyard manure is more effective than any other single substance; it is likely to remain the most important manure, and if available in sufficient quantity it would generally meet the case. Realising its importance, Lord Elveden generously provided funds for extended investigations at Rothamsted into the conditions to be observed in making and storing it. This work is still going on, and is leading to some highly important developments.

Farmyard manure, however, is not available in sufficient quantities to meet all requirements. The chemist has long since come to the aid of the farmer; he has discovered the precise substances needed for the nutrition of the plant, and prepared them on a large scale. Like cultivation, this is largely a British development; it was in London that the first artificial manure factory was established in 1842, and for many years the industry was centred in this country. The fertilisers now available are as follows:—

Nitrogenous—Nitrate of soda, nitrate of lime, sulphate of ammonia, and cyanamide (nitrolim).

Phosphatic—Superphosphate, basic slag, mineral phosphate, guano, and bones.

Potassic—Sulphate of potash, muriate of potash, and kainit.

Agricultural chemists have worked out the proper combinations for particular crops, and obtained many striking results.

Without using any farmyard manure they have maintained, and even increased, the yield of corn crops, fodder crops, and hay; and in the two latter cases there has been an increase, not only in yield, but also in feeding value per ton. In spite of seventy years' experience there is still much to be learned about the proper use of artificial fertilisers, and they may still bring about even fuller yields from the land.

The yield of corn crops can be increased by artificial fertilisers, but not indefinitely; the limit is set by the strength of the straw. As the plant becomes bigger and bigger, so the strain on the straw increases, until finally, when the plant is some 5 ft. high, it cannot stand up against the wind, but is blown down.

Little is known about the strength of straw. It is a property inherent in the plant itself, and differs in the different varieties. It is affected by the season, being greater in some years than in others. It is affected also by soil conditions. At present the strength of the straw is the wall against which the agricultural improver is pulled up. The problem can undoubtedly be solved, and the plant-breeder and soil-investigator between them may reasonably hope to find the solution.

Another great effect of artificial fertilisers which has not yet been fully exploited is to mitigate the ill-effects of adverse climatic conditions. Phosphates help to counteract the harmful influence of cold, wet weather; potassic fertilisers help the plant in dry conditions. The combination of a suitable variety with an appropriate scheme of manuring is capable of bringing about considerable improvement in crop production.

A demonstration with the oat crop on these lines was arranged last year in a wet moorland district, and the crops when seen in August were as follows:

	Estimated crop Bushels.	
Local variety, local treatment ...	27	Harvest late
,, ,, phosphatic manuring	45–54	,, earlier
Special variety "Yielder," phosphatic manuring	54–66	,, earlier, stands up well

The potato crop is governed by the same general principles as corn crops. It furnishes more food per acre than any other crop, but it is much more expensive to produce, and therefore is grown chiefly in districts where the conditions are particularly well suited to it: the Fens, Lincolnshire, the plains of Lancashire, and the Lothians, though smaller quantities are grown in almost every part of the country. The production and consumption are as follows:—

Potatoes: Annual Production and Consumption.

	Production					
	In England and Wales			In United Kingdom		
Consumption	Pre-war 1914	1918	1919	Pre-war 1914	1918	1919
6·5	3·0	4·2	2·7	7·5	9·2	6·3
Millions of acres	0·46	0·63	0·48	1·20	1·51	1·22

We are thus self-supporting in the matter of potatoes. We do, however, import about half a million tons per annum of early and other potatoes; we also export seed potatoes and some for food—in all, about one million tons per annum.

(*To be continued.*)

Notes.

We regret to announce the death, on April 3, at eighty-four years of age, of Capt. E. W. Creak, C.B., F.R.S., formerly Superintendent of Compasses, Hydrographic Department, Admiralty.

The following names were inadvertently omitted from the list of Commanders of the Order of the British Empire (C.B.E.) announced in last week's issue of Nature:—Mr. C. E. Fagan, secretary, British Museum (Natural History); Sir W. H. Hadow, Vice-Chancellor of the University of Sheffield; and Mr. A. R. Hinks, F.R.S., secretary of the Royal Geographical Society.

Lord Sudeley has given notice of the following motion which he proposes to bring before the House of Lords on April 21:—"To call attention to the decision of his Majesty's Government to discontinue the appointment of an official guide at Kew Royal Botanical Gardens; and to move to resolve, That the Government be requested to carry out at these gardens the system of free popular guide-lectures on the same plan as adopted with marked success in the Government museum and picture galleries of the Metropolis, and to take such further steps as after inquiry may be found desirable for developing the resources of these gardens to the fullest extent in the interests of scientific and popular education, together with the recreation of the public."

The Right Hon. F. D. Acland recently asked in the House of Commons whether the Lord President of the Council "is aware that dissatisfaction is being expressed by scientific workers with the appointment of a man without scientific qualifications as director of research to the Glass Research Association; whether, as the Department of Scientific and Industrial Research provides four-fifths of the funds of the association, the Department was consulted before the appointment was made; and does he approve of the appointment as giving a guarantee that State funds devoted to scientific research will be wisely expended?" Mr. Fisher replied to the question, and his answer included the following statements:—(1) The successful candidate has a wide and successful experience of scientific research into the problems of the glass industry, and is considered by the association to be the man best suited for organising and directing the research needed by it. (2) The responsibility for the selection of a director of research rests in each case with the research association concerned, and not with the Department of Scientific and Industrial Research, which has no power to approve or disapprove the appointment of any individual. (3) The Department guarantees three-quarters of the expenditure of the research association up to a certain limit, but payment of the grant is conditional, among other things, on the approval by the Department of the programme of research and of the estimate of expenditure thereon. (4) The Advisory Council of the Department, after considering all the relevant circumstances with great care, recommended the approval of the expenditure involved in this director's appointment.